

# An Investigation of the Effect of Antioxidant on Biochemical Parameters in ELF-EMF Exposure

The effect of ELF-EMF on biochemical parameters

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## Abstract

**Aim:** The purpose of our study was to investigate the effect of electromagnetic fields originating from high voltage lines and antioxidant on serum biochemical values of Wistar albino male rats. **Material and Methods:** A total of 48 rats were included in the study and 3 groups were formed in two different time periods (26/52 days) as follows: Group 1- High voltage (HV), Group 2- HV+Ganoderma lucidum (GL), Group 3- Control. The magnetic field and the electric field were measured. Ganoderma was administered at a dosage of 20 mg/kg/day as a gavage. **Results:** In the implementation that took 26 days, no significant difference was found between groups in terms of AST, ALT, Ca, amylase, glucose ve creatine values ( $P>0.05$ ), and a significant difference was found between groups in terms of urea variable ( $P<0.01$ ). In the implementation that took 52 days, no statistically significant difference was found between groups in terms of AST, ALT, Ca, amylase, glucose, creatine and urea values ( $P>0.05$ ). **Discussion:** It is seen that extremely low - frequency electromagnetic fields generated by high voltage lines may cause changes in serum biochemistry values and the use of some antioxidant (ganoderma) products may be beneficial.

## Keywords

Biochemical Values; High Voltage; Electromagnetic Field; Ganoderma, Rat

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## Introduction

With the development of technology, electromagnetic field exposures increase. The extremely low frequency electric and magnetic field exposures caused by the electrical energy used from 50 Hz power frequency cause concern in the society. Based on limited epidemiological evidence, in 2002 the International Agency for Research on Cancer (IARC) classified ELF-MF as a possible carcinogen for humans [1]. It is emphasized that working on long term high voltage lines will have negative consequences on human health [2]. However, for many years, researchers have not been able to fully establish a validated correlation of the impact of electromagnetic radiation on human health. The debate on this issue is still ongoing [3]. In recent years, the use of electricity in industry and households has been increasing. The need for electricity leads to an increase in high-voltage lines. High voltage systems are located in the 50/60 Hz frequency band. It is emphasized that the formation of ionic dipoles cause changes in membrane potential and can affect biochemical processes in cells, as electric fields can penetrate into the body [4, 5]. The electromagnetic fields that we encounter in our daily lives have a frequency of 3-300 Hz. They are particularly described as extremely low frequency electromagnetic fields (ELF-EMFs). Studies on the impact of these areas on public health and employee health are insufficient. ELF-EMF domains have effects on metabolic and biochemical processes [6]. In case of continuous exposure to or induction of electric fields, various biological processes can be initiated. It is emphasized that changes in exposure may lead to changes in renal and liver functions [7].

Ganoderma is used in the treatment and prevention of various diseases, especially in eastern countries. Ganoderma is used to prevent oxygen radicals and oxidative damages. It has a protective effect against DNA damage caused by UV radiation and has a good radioprotective effect [8]. Ganoderma, commonly used in traditional Chinese medicine to promote health and longevity, has been widely accepted as herbal supplements. The medical properties of GL can be attributed to antioxidant and anti-inflammatory activities [9]. Ganoderma lucidum may be useful in the treatment of chronic liver damage and in strengthening the body's antioxidant capacity [10].

It is now impossible to avoid electromagnetic field exposures. These areas are risk and concern. We have created a high voltage line model in the laboratory environment. In this study, we aimed to investigate the effects of a very low-frequency electromagnetic field and antioxidant (Ganoderma lucidum) on some biochemical values.

## Material and Methods

### Animals and experimental protocol

A total of 48 Wistar albino male rats were included in this study. Rats were divided into 3 groups in two different time periods (26 days and 52 days) as follows: Group 1- High voltage group (HV), Group 2- High voltage+Ganoderma (GL), Group 3- Control. Experimental groups were exposed to daily 8 hours during 26 and 52 days. The animals were maintained in an appropriate medium (12 hours light/dark, the temperature of  $23 \pm 1$  °C, and 45-55% humidity). Ganoderma (Gano Excel, Industries Sdn. Bhd., Kedah, Malaysia) extracts were prepared with distilled wa-

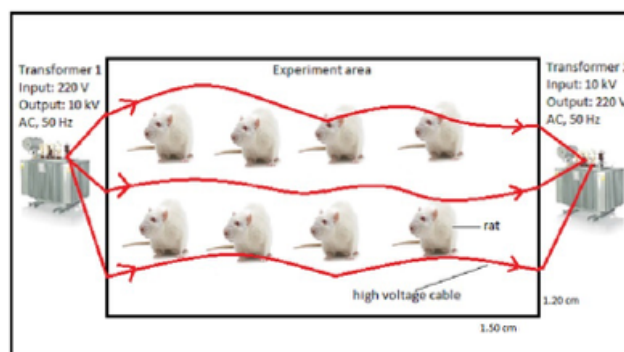
ter according to appropriate standards. Ganoderma was given at a dosage of 20 mg/kg/day as a gavage. Two separate transformers were used to generate the electromagnetic field (for the first transformer, the input was 220 volts, and the output was 10 kilovolts (10kV). For the second transformer, the input was 10 kilovolts, and the output was 220 volts and 5,000 volts amps). Electromagnetic field measurements were performed using Spectran NF5035 (Aaronia, Germany) model device. Electromagnetic field measurements were made in plexiglass cages where rats were encaged during the experiment. Daily measured areas were averaged. The readings were taken in volt per meter (V/m) for the electric field and microTesla ( $\mu$ T) for the magnetic field. Field measurements were 80.3 V/m for electric field and 2.48 microTesla for the magnetic field. Figure 1 shows the experimental setup. This study protocol was initiated after the approval of the Kirsehir Ahi Evran University Animal Ethics Local Ethics Committee decision (AEUHADYEK, 30/10/2019, 20-2) and the study continued according to the standards set out in the Helsinki Declaration.

### Blood collection and analysis of biochemistry parameters

At the end of the work, the rats were anesthetized with intramuscular injection (1ml for one rat (0.1 cc xylazine + 0.9 cc ketamine)). Then, the blood of the rats from the intracardiac route was drawn. Blood samples from the control and experimental groups of animals were collected (BD Vacutainer 5.0 ml, UK). Serum was separated directly by centrifugation (NF 1200 R Nuve, Turkey) at 5000 rpm for 5 minutes and was kept at -20°C until the analysis. An automated analyzer method was applied for the analysis of the data (Abbott Architect® c16000).

### Statistical analysis

The normality hypothesis was tested by the Kolmogorov-Smirnov and the Shapiro-Wilk tests. The Levene test was used to test the assumption of homogeneity of variances. For the comparison of the groups in the study, ANOVA was used. Comparison of the groups which revealed significant difference was analyzed through DUNCAN multiple comparison test. Descriptive statistics of variables are given as Mean  $\pm$  Standard deviation. In all statistical analyses, cases with a p-value less than 0.05 were interpreted as statistically significant. Statistical analysis of the study was performed using Statistical Package for Social Sciences version 21.0 software for Windows (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp., USA).



**Figure 1.** Experimental setup

Results

Three different groups (HV, HV+Ganoderma and Control) were tested during two different processes (26 and 52 days) in the study. Statistics of the groups during 26 days of implementation and the results of the analysis are displayed in Table 1. According to the results revealed in Table 1, the difference between the groups was not found significantly related to the AST, ALT, Ca, amylase, glucose and creatine values (P>0.05). The difference between the groups relating to the urea variable is found statistically significant (P<0.01). The value of urea in the control group was lower than Group 1 and Group 2. Statistics of 52 days of implementation of the groups are displayed in Table 2. According to the results in Table 2, no significant difference was found between groups in terms of AST, ALT, Ca, amylase, urea, glucose and creatine values. (P>0.05). Statistics of 52 days of implementation of the groups are displayed in Table 2. According to the results in Table 2, no significant difference was found between groups in terms of AST, ALT, Ca, amylase, urea, glucose and creatine values. (P>0.05).

Discussion

Peighambarzadeh and Tavana in their study, included participants who worked in high voltage electric line for at least ten years. The serum of the blood drawn in the study was analyzed. They found a statistically significant change in AST and urea values in control and experimental group comparisons, but a statistically insignificant change in ALT, glucose, creatine and Ca parameters [2]. Researchers investigated the effect of electromagnetic radiation resulting from cell phones with 500-900

MHz frequency on 60 swiss albino mice during two different time periods of 20 and 40 days. They found a decrease in serum creatine and glucose levels and an increase in serum AST and ALT levels in long-term exposures [3]. Coşkun et al. emphasized that the 50 Hz electric fields reduced some of the serum biochemistry (plasma total cholesterol and triglyceride rates) characteristics. It is stated that the mechanism of action of electric fields is not fully understood yet [11]. The researchers found that 50 Hz magnetic fields had no significant effect on growth or most of the biochemical parameters of blood, except for creatine and cholesterol. However, changes in creatinine and cholesterol have been found to be relatively small [6]. DNA damage was investigated by exposure to electromagnetic field on workers working in the power line in Iran. As a result of the study, a significant increase (p<0.05) was found in the workers' tail moment and DNA tail percentage in experimental and control groups comparisons [12]. Lai et al. found that exposure to 100µT- 50 Hz ELF EMF for 20 hours per day for 3 months would not affect blood hematogram and blood biochemistry (including lipid profile, blood glucose, liver function and renal function of rats) in the experimental and control groups [13]. In our study, it is found out that there is an increase in the high voltage group of AST, ALT, amylase and urea values in comparison with the parameters of 26 and 52 days of implementation with the control group and a decrease in glucose group. It is found that Ca values of 26 days of high voltage group increased compared to the control group, and no significant change was revealed during 52 days of exposure. This study also revealed that no significant difference was found in creatin values of

Table 1. Descriptive statistics of 26 days of implementation and the results of the analysis

Time	Groups	AST (IU/L)	ALT (IU/L)	Ca (mmol/L)	Amylase (IU/L)	Urea (mmol/L)	Glucose (mmol/L)	Creatine (µmol/L)
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
26 day	Group 1 HV	153.0±49.77	49.5±2.82	9.0±0.51	968.3±107.7	44.5±4.56a	176.0±47.3	0.48±0.02
	Group 2 HV+GL	117.7±24.33	45.5±4.0	9.0±0.61	921.0±113.3	43.5±4.65a	229.5±61.2	0.46±0.05
	Group 3 Control	111.2±47.89	47.2±10.4	8.81±0.49	955.3±110.3	36.0±4.14b	224.0±65.9	0.48±0.04
		<sup>ns</sup> 0.129	<sup>ns</sup> 0.495	<sup>ns</sup> 0.594	<sup>ns</sup> 0.680	*0.002	<sup>ns</sup> 0.159	<sup>ns</sup> 0.762

There is no significant difference between the means indicated by the same letter in the same column (P>0.05.) There is a significant difference between different alphabetic groups. \*A significant difference found between the groups (P<0.05). <sup>ns</sup>No significant difference found between the groups (P> 0.05). SD: Standart deviation, AST: aspartate aminotransferase, ALT: alanine aminotransferase, Ca: Calcium.

Table 2. Descriptive statistics of 52 days of implementation and the results of the analysis

Time	Groups	AST (IU/L)	ALT (IU/L)	Ca (mmol/L)	Amylase (IU/L)	Urea (mmol/L)	Glucose (mmol/L)	Creatine (µmol/L)
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
52 day	Group 1 HV	103.5±49.9	51.2±6.92	8.8±0.62	822.7±72.86	34.87±3.04	189.1±49.82	0.45±0.03
	Group 2 HV+GL	85.1±36.61	48.6±10.32	9.1±0.64	844.6±91.42	34.6±7.28	209.0±51.96	0.47±0.03
	Group 3 Control	87.3±13.26	47.7±9.88	8.5±0.84	820.3±122.64	33.12±3.36	224.5±43.45	0.44±0.03
		<sup>ns</sup> 0.557	<sup>ns</sup> 0.733	<sup>ns</sup> 0.277	<sup>ns</sup> 0.862	<sup>ns</sup> 0.750	<sup>ns</sup> 0.362	<sup>ns</sup> 0.442

<sup>ns</sup>No significant difference was found between the groups (P> 0.05). SD: Standart deviation.

26 days of high voltage group; and an increase was found in 52 days of implementation according to the control group. In the literature, similar to our study, it is revealed that AST and ALT values are consistent with an increase in the experimental group. Likewise, the results of amylase, urea, Ca, glucose and creatine are similar to the results as in the literature. However, some studies have indicated that there is no change in electromagnetic field exposures.

There are many studies on the protective effect of ganoderma. Ganoderma triterpenoids reduced oxidative stress and inflammation in liver injuries, and because of its rich biological activity, it was emphasized that it may play a role in minimizing the effects of electromagnetic induced exposures and damages in various tissues [10, 14, 15, 16]. In this study, when high voltage (HV) group and HV+GL group are compared, AST and ALT values in HV+GL groups were found lower in 26 and 52 days of implementation. No significant difference was found in Ca and urea groups. As the implementation process increases, it is seen that values in the parameters of amylase, glucose and creatin in HV+GL group increased. In this study, according to results of 26 and 52 days of HV groups, a decrease in AST, ALT, urea and amylase and glucose values may indicate a protective effect of ganoderma.

Although the biophysical and biochemical mechanisms of the biological effects of EMF at low-density levels are not fully known, significant progress has been made in recent years, and there is a great deal of data indicating that these mechanisms can overlap the effects of ELF and RF [17]. Many studies have shown that transduction of weak electrical signals in the ELF range involves interactions with the cell membrane, resulting in cytoplasmic biochemical responses involving changes in cellular functionality and proliferative states [18]. Although the electrical and magnetic field values measured in our study are below the limit values of the International Commission on Non-Ionizing Radiation Protection, it is seen that they can cause some changes in biochemical parameters that is investigated in this study.

### Conclusion

In our study, it was found that extremely low-frequency electromagnetic fields caused some increases and partially decreases in serum biochemistry parameters of rats. It is thought that Ganoderma may have shown a possible protective effect. However, in the literature, it is seen that the mechanism of effect on biochemistry parameters is not fully known and further researches on effects of ELF-EMF are needed.

### Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

### Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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### Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

### References

1. Y Fei, L Su, H Lou, C Zhao, Y Wang, G Chen. The effects of 50 Hz magnetic field-exposed cell culture medium on cellular functions in FL cells. *J Radiat Res.* 2019; 60(4): 424-31.
2. Sert C, Yazgan P. Bone quality, biochemical and blood markers in high power electrical workers. *J Int Dent Med Res.* 2017; 10 (3): 1042-47.
3. Peighambarzadeh SZ, Tavana M. Effects of electromagnetic field radiation on biochemical parameters in swiss albino mice. *Banats J Biotechnol.* 2017; 8(16): 48-53.
4. Forgacs Z, Thuroczy G, Paksy K, Szabo DL. Effect of sinusoidal 50 Hz magnetic field on the testosterone production of mouse primary Leydig cell culture. *Bioelectromagnetics.* 1998; 19:429-31.
5. Sadeghi H, Zare S, Hayatgeibi H, Alivandi S, Ebadi AG. Biological effect of power frequency magnetic fields on serum biochemical parameters in Guinea pigs. *Pak J Biol Sci.* 2006; 6: 1083-87.
6. Luo X, Ma L, Gao P, Zhang Y. Effects of subchronic extremely low-frequency electromagnetic field exposure on biochemical parameters in rats. *Toxicol Ind Health.* 2017; 33(4): 365-72.
7. Kulkarni GA, Gandhare WZ. Effect of extremely low frequency electric field on liver, kidney, and lipids of Wistar rats. *Int J Med Sci Public Health.* 2015; 4(12): 1755-60.
8. Kim KC, Kim IG. Ganoderma lucidum extract protects DNA from strand breakage caused by hydroxyl radical and UV irradiation. *Int J Mol Med.* 1999; 4(3): 273-80.
9. Hsu PL, Lin YC, Ni H, Mo FE. Ganoderma triterpenoids exert antiatherogenic effects in mice by alleviating disturbed flow-induced oxidative stress and inflammation. *Oxid Med Cell Longev.* 2018; 3491703. DOI: 10.1155/2018/3491703.
10. Li T, Yu Haroran, Song Y, Zhang R, Ge Ming. Protective effects of Ganoderma triterpenoids on cadmium-induced oxidative stress and inflammatory injury in chicken livers. *J Trace Elem Med Biol.* 2019; 52: 118-25.
11. Coskun O, Çömlekçi S. Effect of ELF electric field on some on biochemistry characters in the rat serum. *Toxicol Ind Health.* 2010; 27(4): 329-33.
12. Zendehele R, Yu II J, Hajipour-Verdo B, Panjali Z. DNA effects of low level occupational exposure to extremely low frequency electromagnetic fields (50/60 Hz). *Toxicol Ind Health.* 2019; 35(6): 424-30.
13. Lai J, Zhang Y, Zhang J, Liu X, Ruan, Chaugai S, et al. Effects of 100-μT extremely low frequency electromagnetic fields exposure on hematograms and blood chemistry in rats. *J Radiat Res.* 2015; 57(1): 16-24.
14. Doğan MS, Yavaş MC, Yavuz Y, Erdoğan S, Yener İ, Şimşek İ, et al. Effect of electromagnetic fields and antioxidants on trace element content in rat teeth. *Drug Des Devel Ther.* 2017; 11: 1393-98.
15. Tanık A, Yavaş MC. The protective effect of melatonin and ganoderma lucidum against the negative effect of extremely low-frequency electromagnetic fields (EMF) on alveolar bone of rats. *Anal Quant Cytol.* 2019; 41(2): 55-66.
16. Doğan MS, Yavaş MC, Günay A, Yavuz İ, Deveci E, Akkuş Z, et al. The protective effect of melatonin and ganoderma lucidum against the negative effects of extremely low frequency electricity and magnetic fields on pulp structure in rat teeth. *Biotechnol Biotechnol Equip.* 2017; 31(5): 979-88.
17. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, et al. EURO-PAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. *Rev Environ Health.* 2016; 31(3): 363-97.
18. ICNIRP Guidelines. For limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz). *Health Phys.* 1998; 74(4): 494-522.

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